

THE ROLE OF ACOUSTICS IN THE PLANNING OF PERFORMANCE HALLS IN COPENHAGEN

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Abstract: At present, three new, large cultural venues are underway in Copenhagen: A new opera, a new concert hall and a new drama theatre. In all three cases, acoustics was a major factor behind the decisions made in the planning stage. In the cases of the opera hall and concert hall, an earlier political decision suggesting building of a combined concert- and opera hall was changed after an analysis of the limited acoustic potential in such a combined hall. The new opera is been donated by the oil and shipping company Maersk, while the Danish Radio will build the concert hall in their new headquarters in Ørestaden, Amager. The acoustic analysis mentioned also formed the basis for choice of basic shape of the concert hall. The paper will describe some elements of this analysis, acoustic demands set up in the design competition briefs for the concert hall and drama theatre and finally the unusual procedure applied in the choice of acoustician for the design of the concert hall.

Keywords: Architectural Acoustics, architects competitions, opera halls, concert halls, theatres.

1. HISTORICAL BACKGROUND

In 1999 the Danish government attempted to coordinate the demands for future cultural venues in Copenhagen, which for many years had been expressed from various corners of the established performing arts community. These demands included a new concert hall for symphonic music, a new, larger opera theatre and a new drama theatre for the Royal Theatre.

1.1 Drama hall projects

Let us start by sketching the history of the drama theatre plans, as this history is somewhat independent from those of the concert hall and opera.

Plans for a new drama theatre which would allow a more flexible lay out of stage and audience than the current "Old Stage" in the Royal Theatre – an Italian Baroque style theatre with fixed proscenium - have been discussed for many years, and the last three decades have brought three architect's competition: in 1979 (won by the Danish KHR architects), in 1995 (won by the Norwegian architect Sverre Fehn) and in 2002 won by Danish architects Boje Lundgaard and Lene Tranberg.) Whereas the first two competitions required the new theatre to be placed in conjunction with the existing Royal Theatre at Kongens Nytorv, the latest project is located a few hundred metres away, at Sankt Annae Square at the water front.

One major argument against a new drama theatre has been, that already in 1931 the Royal Theatre actually got its "New Stage" for drama (however then scheduled to be shared with the young Danish Radio's demand for a concert hall/studio). Although this building was heavily criticized already from day one (the Danish Radio moved

out again only ten years later !), it is still standing – and will continue to do so as it has been protected due to its rich Art Deco architecture. In 2001 it was renovated [1] and turned out to have room for only 450 modern, comfortable seats - only half of the original capacity. Therefore, this theatre is now obviously too small to house the national drama stage.

With the latest design competition having survived the change in government in 2001, it seems that - finally – a proper national drama theatre will be realized. The design work for the Sankt Annae Square project is likely to start September 2002. This new drama theatre will have 750 seats in the main auditorium plus a smaller "black box" stage with 250 seats. In the acoustic brief for the architects competition, the need for sufficient sound levels and intelligibility of speech was emphasised. It was also suggested that the reverberation time should be variable in order to accommodate various kinds of music theatre performances. However, as spoken drama has top priority, this variation may just be provided by electro acoustic reverberation enhancement.

1.2 Concert hall projects

In 1999, the situation regarding concert halls in Copenhagen was as follows. Soon there would only be one "proper" but not quite up to date concert hall left, the Tivoli Concert Hall (built 1956, 1800 seats) [2]. The much loved, old shoe box concert hall in Odd Fellow Palæet (1886, 1400 seats) [3] had burned down in 1992 and the Danish Radio had plans to leave and sell the Radiohuset with its 1100 seat concert hall (Studio One) [2], as they would unite their Copenhagen radio and television activities in a new "multi media" broadcasting house in Ørestaden, the new part of Copenhagen on the island Amager. The question then was, whether this new media center should include a concert hall or not.

Now, this historical revue would not be complete without mentioning that an architect's competition for a new concert hall had also been conducted by the Copenhagen city council in 1993; but already in his speech of thanks, the winning architect, Henning Larsen, killed the project by heavily criticizing the conditions laid down in the programme. (His arguments were sound, however !)

1.3 Opera needs

The Royal Opera experienced an increase in popularity up through the 1990-ies and the physical limitations of The old Stage in the Royal Theatre (1874, 1400 seats) [4] could well justify a new, larger opera house more suitable for the larger orchestras demanded in the romantic opera repertoire, e.g. Wagner and Strauss and with a larger stage favoured by modern stage set designers and ballet choreographers alike. Also the highly popular modern musicals could be catered for in such a venue. Still, the need for a new opera seemed less urgent than the need for a new concert hall.

1.4 Concerts and opera together ?

As some parties in parliament found building three new large cultural venues in a city like Copenhagen extravagant, the idea came up of combining the opera and concert hall in one auditorium. This was formulated in a political resolution made in April 1999: "... a committee should be formed with members from the Danish Radio, The Royal Theatre and relevant experts. The group will be given the task to suggest how in connection with the [new] Danish Radio Concert Hall, an opera stage can be established with a technical/acoustical solution, which makes it possible to hold orchestra rehearsals and -concerts on the opera stage." (unauthorized translation). The author was happily surprised to see the word "acoustics" mentioned in such a political text, and afterwards to find himself appointed as the "relevant expert". Surely, the importance of acoustics had reached the highest level of decision makers. On the other hand, it was worrying that the wording of the document seemed to indicate a predisposition for a combined solution.

2. TEACHING ACOUSTICS TO EXECUTIVES

As the author was convinced that a combined hall was a very risky platform for achieving an excellent acoustic result – and as a new performance venue would not be able to attract international attention unless the highest standards of excellence was aimed for, it was necessary to produce a document which could explain why different shapes are chosen by present day designers of halls dedicated for symphonic concerts and opera performances respectively, and what qualities are likely to be sacrificed if one wants to combine both functions in one hall. All this should be presented in a non-technical manner – to be read by politicians. The efforts materialized in a report:

"Room acoustic conditions in halls for opera, for concerts - and for both" [5] in which was described:

1: the different aspects of room acoustic perception and how they relate to the choices of shape and materials in the hall, and

2: the trends in modern opera and concert hall design with emphasis on how the two types of halls seems to be moving in different directions – largely as a consequence of attempts to cultivate different acoustic preferences for concerts and opera.

The different room acoustic aspects explained were:

- Relative loudness (Strength)
- Fullness of tone / reverberance
- Clarity
- Spaciousness
- Timbre / Tonal colour
- Musicians needs for hearing others and for support to their own sound

For each of these qualities it was briefly described how they relate to room volume, absorption area and room shape (as responsible for generation of early reflections).

2.1 Trends in opera hall design

Examples of old and newer opera halls (horse shoe and other shapes) were then presented leading to the conclusion that modern halls for opera (at least in Europe) are being designed very much on the basis of the Italian baroque theatre format: a horse shoe shaped floor plan and balconies in several levels. Examples from the last decade are found in Glyndebourne, Helsinki, Oslo and Göteborg. In these designs this room concept has improved from many shallow balconies with boxes into fewer, open balconies, better seating comfort and sight lines; whereby its original virtues has an even higher probability of being realized:

- moderate reverberation times (as most of the wall area is covered by audience),
- high sound levels (in the moderate room volumes), and
- high clarity due to many close surfaces and short audience/stage distances, which also ensures visual (and acoustical) intimacy.

In later years, slightly higher reverberation times for opera as found in the Semper Oper, Dresden with values above 1.5 Sec., have been popular in Scandinavia; but with

modern prediction tools to analyse and control the early reflection sequence (e.g. through the design of the proscenium walls and the lay out of balconies), this does not imply that clarity needs to be sacrificed.

2.2 Trends in concert hall design

Contrary to the tradition in opera hall design, the acoustic yard stick for concert halls developed from the qualities inherent in the classical rectangular (shoe box) concert halls (in Vienna, Amsterdam etc.):

- a strong sense of reverberance due to a high volume per seat ratio and all surfaces in the upper half of the hall being reflective, as the balconies for audience reach only halfway up the walls, and
- a high degree of spaciousness due to the limited width of the room.

Still, the development of concert halls has not only been a refinement of the “shoe box”. After a long period in the last century dominated by fan shaped designs (which

provided high clarity but low reverberance and poor spaciousness), a number of designers have tried to develop halls having high reverberance as well as the high clarity we have got used to from the electronic media. Obtaining both qualities requires a large volume as well as close reflecting surfaces. These demands seem contradictory, as normally the reflecting surfaces move away as the volume increases, so the solution is to design the reflecting surfaces independent of the boundaries defining the volume. In halls designed by Artec, USA [2], this is obtained by adding an extra volume to a modest sized “shoe box” auditorium, whereas Harold Marshall in his “Directed Reflection Sequence” halls in New Zealand [2] start with a large main volume and place large, dedicated reflecting surfaces inside the volume to ensure high clarity, strength and spaciousness. However, also the vineyard concept by Cremer first seen in Berlin can be used this way: the main volume may be designed to ensure sufficient reverberance, while the terrace walls created by clever subdivision of the seating can generate suitable early reflections independently.

Hall shape	Function	Strength	Reverberance/ Fullness	Clarity	Spaciousness	Intimacy (vis/audit)	Change of function
Horse shoe	Concert Opera	+ +	- too little +	- too much +	- too little [+]	[+] +	Easy (Orch. Shell)
Fan	Concert Opera	+ +	- too little +	- too much +	- too little [-]	[+] - too little	Easy (Orch. Shell)
Shoe box	Concert Opera	+ +	+ - too much	+ - too little	+ [+]	[-] - too little	Easy (Orch. Shell)
Arena/ Vineyard	Concert Opera	+ - too low	+(a little low) +	+ +	+ [+]	[+] - too little	Complicated

TABLE 1: Potential quality of different acoustic aspects for different hall shapes for symphonic music and opera performances respectively. “+” means that the particular combination of hall shape and function (concert or opera) has a high probability of providing satisfactory conditions with respect to the acoustic aspect at the top of the column. “-“ means low probability. “[]” means that this particular acoustic aspect might be of less importance for a particular function. Also the ease of changing function from opera to concerts has been listed.

2.3 Combined halls

On this basis, one might dare to evaluate the acoustic potential for a combined opera and concert hall as outlined in Table 1, in which the likely acoustic properties of each basic hall shape is compared with the requirements for excellence in relation to both opera and symphonic concert performances. Also the questions of visual and acoustic intimacy and ease of transforming the hall between the opera and concert functions are commented on. In the case of the vineyard with audience surrounding the stage, such a transformation is very complicated ! An example of a combined hall of (almost) vineyard style is the Megaron hall in Athens, where a dedicated opera hall is now being built next door.

Also touched upon in the report was the demand for variable volume for change of reverberation time between

opera and concert, as adding absorption to reduce the reverberation for opera is a very bad idea due to lack of sound energy. The picture may be further complicated, if also a change in seating capacity between the two functions are called for.

The conclusions of the report can be seen from Table 1: Regardless of choice of basic shape for a combined hall, compromises in acoustic quality must be expected for either opera or concerts. On the other hand, recommended shapes for a dedicated concert hall could be either shoe box or vineyard, while for opera the horse shoe is still the most likely to be successful.

Consequently, the committee concluded its work by recommending building of two separate halls. It should be mentioned, however, that apart from acoustics, also other factors led to this conclusion, as it was also found to be

very difficult for two full time institutional companies, the Danish Radio Symphony Orchestra and the Royal Opera/Ballet, to share one facility (as already proven in 1931 ! [1]).

2.4 The new opera

Almost before the Danish government had digested the recommendations from the group, reality developed ahead of the planning. In spring 2000, the owner of the large shipping company Maersk announced that he would donate a site at the harbour front and the new opera building as well. The company had already chosen Henning Larsen as architect and within half a year also the engineers, the acoustician (Arup Acoustics) and the theatre consultant. As far as we know the auditorium will be designed to seat 1400 and the stage will be substantially larger than the present "Old Stage". Design as well as construction is currently (August 2002) well advanced.

After this generous donation to the city, all that was left for the government to do was to let DR build its own concert hall in Ørestaden - and to secure state funding and progress of the drama theatre project, of course.

2.5 The new DR concert hall

Based on the acoustic analysis described earlier, the Danish Radio made a choice between the shoe box and the arena shapes (vineyard or Marshall-DRS formats). They chose the arena largely because of the more "democratic" and intimate idea of the audience surrounding the orchestra as the focal point instead of the musicians being separated from the audience by an invisible veil at the stage front. Upon this decision the author - as acoustic advisor for the client - suggested a number of halls for the DR board of governors to visit in Europe, Japan, USA and New Zealand.

Whenever there was a chance to attend a concert or an orchestral rehearsal in the halls visited, the board members were asked to fill out copies of Mike Barron's questionnaires [6] in order to make them consider the different acoustic aspects and to help them structuralize their acoustic experiences. Fig. 1 shows their overall acoustic judgements of the halls visited.

Obviously, this result should not be regarded as a scientific ranking of these halls, as many sources of error and bias are present. Still, it was interesting to observe that without prior training in acoustics these people were able to handle a questionnaire like Barron's and produce a clear and statistically significant result.

The importance of acoustics in the eyes of the Danish Radio is also clearly reflected in the uncommon procedure chosen for the selection of acoustician for the project. Prior to the architect's competition, a pre qualification of acoustic consultancy firms was organized. Subsequently,

a list of eight pre qualified acousticians was issued for the competing architects to choose from. The winning architect - including his selected acoustician and engineers - would then be given the job. The architects participating in the competition were partly invited (three teams) and partly chosen after pre qualification (five teams). Among these, three ended up choosing Arup Acoustics, two chose Nagata Acoustics, another two chose Akustikon/Bo Mortensen and one picked Jordan/Rindel/Ingemansson.

In the competition programme, a 1600 seat concert hall with 200 extra seats for choir was asked for. The volume was specified to no less than 22.000 m³ and mid frequency reverberation time to at least 2.3 Sec. with a possibility of reducing the value to 1.6 Sec. for amplified music - e.g. concerts by the DR Big Band. Further it was emphasized that the acoustic conditions for the musicians should be dealt with properly - which is not a small challenge in an arena shaped hall. Besides the concert hall, this segment (segment four) of the large DR complex in Ørestaden will also contain three other major studios with possibilities of audience attendance.

The winner became Atelier Jean Nouvel cooperating with Nagata Acoustics. This pleased the DR board of governors, as in particular they had liked the Sapporo concert hall in Japan in which the acoustic design was made by this firm.

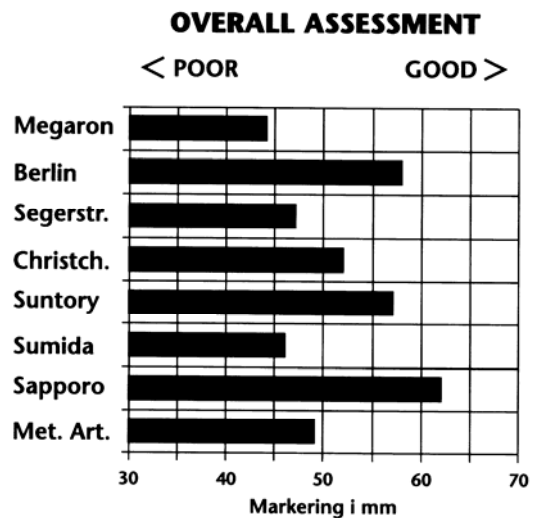


Fig. 1: Overall judgement of acoustic excellence of halls visited by DR board members in 2000 - 2001. Average of up to nine responses for each hall. The halls are: Megaron in Athens, Philharmonie Berlin, Segerstrom Hall in Costa Mesa California USA, Christchurch Town Hall New Zealand, Suntory Hall, Sumida Concert hall and Metropolitan Art Space Concert hall all in Tokyo, and Sapporo Concert hall "Kitara" in Sapporo Japan.

The design of the new concert hall for the Danish Radio started spring 2002.

3 CONCLUSIONS

With three new, large performing arts facilities well in preparation (all are planned for inauguration between 2005 and 2007), Copenhagen can look forward to becoming highly visible on the cultural map of Europe.

With the acoustic conditions being given such a high priority in the planning and design as demonstrated above, we can also hope that Copenhagen will become famous for exposing the state of the art in architectural acoustics.

REFERENCES

1. A. C. Gade, "Acoustic renovation of two Danish theatres". Proceedings of the Institute of Acoustics; London, July 2002.
2. L. L. Beranek, "Concert and opera halls; how they sound". Acoustical Society of America, 1996.
3. A. C. Gade, "Akustik I danske koncertsale". Publication No. 22, The Acoustics Laboratory, Technical University of Denmark 1984. (In Danish)
4. A. C. Gade, B. Mortensen; "Compromises in orchestra pit design". Proceedings of the 16th ICA, Seattle, Washington, June 1998.
5. A. C. Gade, "Rumakustiske forhold I sale til opera, til koncert – og til begge dele". Danish Ministry of Culture. October 1999. (In Danish)
6. M. Barron, "Subjective Study of British Symphony Concert Halls". *Acustica* Vol. 66, p. 1-14, 1988.